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UNDERGRADUATE-PILOT-TRAINING DUTY SCHEDULES AND AIRCREW FATIGUE

Stephen M. Rokicki, Ph.D.
William F. Storm, Ph.D.
Murray L. Durant, Airman First Class, USAF
Richard J. Fulton, Captain, USAF (Reese Air Force Base, Texas)

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USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

Volenti Subvenimus

NOTICES

This final report was submitted by personnel of the Crew Performance Branch, Crew Technology Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7930-10-28.

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The operational personnel who participated in this study were fully briefed on all procedures prior to participation in the study.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

STEPHEN M. ROKICKI, Ph.D.
Project Scientist

William F. Storm
WILLIAM F. STORM, Ph.D.
Supervisor

Roy L. DeHart
ROY L. DEHART
Colonel, USAF, MC
Commander

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*National Research Council - USAFSAM postdoctoral research associate

**64th Flying Training Wing/Safety Office (64 FTW/SE), Reese Air Force Base, Texas

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During USAF undergraduate pilot training (UPT), instructors and students alternate weekly between an early-reporting (0530) and late-reporting (1030-1230) daily work schedule. A preliminary study was conducted to evaluate the effects of the alternating weekly schedule on pilot fatigue and sleep. Both student and instructor pilots reported a modest fatigue level when they began their early-morning duty days. Its only operational impact would be due to the fact that

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performance deterioration is more apt to occur in new, unmastered tasks, and UPT is a learning situation for the students. Beginning the early-week duty days a little later (0630-0700) may result in a notable reduction in early-morning pilot fatigue and sleepiness. At minimum, the findings provide empirical data for instructing the pilots on the importance of acquiring adequate sleep.

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UNDERGRADUATE-PILOT-TRAINING DUTY SCHEDULES
AND AIRCREW FATIGUE

INTRODUCTION

During the 50 weeks of USAF undergraduate pilot training (UPT), instructors and students alternate weekly between an early-reporting and late-reporting daily work schedule. This split schedule permits maximum use of aircraft and assures adequate exposure to nighttime flying as the students progress through phases of training. The early schedule requires a reporting time of about 0530, while those on the late schedule report from 1030-1230. Most training occurs during the standard 5-day work week, and a typical day includes both academic instruction and flight training. At the request of the Safety Office of the 64th Flying Training Wing (ATC), Reese AFB, Texas, the Crew Performance Branch of the USAF School of Aerospace Medicine (USAFSAM/VNE) conducted an exploratory study* to evaluate the effects of the alternating weekly schedule on pilot fatigue and sleep schedules.

METHOD

The Subjective Fatigue Checkcard (SAM Form 136) and the Sleep Survey (SAM Form 154) have been used successfully to evaluate crew stress and fatigue in a variety of airborne and ground operations (3-6,11,12). These self-administered surveys have been selected and developed to minimize interference with operational duties, daily schedules, and personal activities. The Sleep Survey (Fig. 1) documents the hours slept during each 24-hour period and requires about 1 minute to complete. The Subjective Fatigue Checkcard (Fig. 2) can be completed in less than a minute and results in a score ranging from 0-20 (arbitrary units), with lower scores indicating greater fatigue (10). In general, subjective fatigue scores above 11 indicate feelings of alertness, scores of 11 to 8 relate mild to moderate fatigue, and scores of 7 and below indicate severe fatigue.

Prior to the study, all participants were briefed on the purpose, procedure, and data collection schedule for both surveys so that individuals could assume responsibility for the proper and timely collection of their own data. The large ratio of participants to investigators, the individual schedule of each participant, and the need for some at-home data collection made a self-administrative methodology practical and efficient.

Fifty-five student and instructor pilots assigned to the 35th (T-37 aircraft) or the 54th (T-38 aircraft) Flying Training Squadrons participated in the study. Each participant was directed to complete a Sleep Survey and an initial Subjective Fatigue Checkcard each day within an hour or so of arising.

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*Data collection (July-August 1980) was monitored by Captain Richard J. Fulton of the Training Wing.

SLEEP SURVEY

NAME (Last, First, MI)	GRADE	DATE/TIME

1. On the chart below, mark an X in each half hour interval you slept yesterday and today.

YESTERDAY

MID-NIGHT 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 MID-NIGHT

TODAY

MID-NIGHT 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 MID-NIGHT

2. HOW MUCH TROUBLE DID YOU HAVE GOING TO SLEEP LAST NIGHT?

☐ NONE ☐ SLIGHT ☐ MODERATE ☐ CONSIDERABLE

3. HOW RESTED DO YOU FEEL?

☐ WELL RESTED ☐ MODERATELY RESTED ☐ SLIGHTLY RESTED ☐ NOT AT ALL

4. DO YOU FEEL LIKE YOU COULD HAVF USED SOME MORE SLEEP?

☐ YES ☐ NO

SAM FORM 154 SEP 76 PREVIOUS EDITION WILL BE USED REMARKS ON REVERSE

Figure 1. SAM Form 154: Sleep Survey.

NAME AND GRADE		TIME/DATE	
INSTRUCTIONS: Make one and only one (X) for each of the ten items. Think carefully about how you feel RIGHT NOW.			
STATEMENT	BETTER THAN	SAME AS	WORSE THAN
1. VERY LIVELY			
2. EXTREMELY TIRED			
3. QUITE FRESH			
4. SLIGHTLY POOPED			
5. EXTREMELY PEPPY			
6. SOMEWHAT FRESH			
7. PETERED OUT			
8. VERY REFRESHED			
9. FAIRLY WELL POOPED			
10. READY TO DROP			

PREVIOUS EDITION WILL BE USED

SAM FORM SEP 76 136 SUBJECTIVE FATIGUE CHECKCARD

Figure 2. SAM Form 136: Subjective Fatigue Checkcard. Lower scores indicate greater fatigue.

For the remainder of the day, additional fatigue checkcards were to be self-administered upon completion of each major training activity, which was anticipated to be about once every 4 hours. Sleep and fatigue data were collected daily for 4 successive weeks, including weekends and other off-duty days. As on training days, fatigue checkcards were to be completed about every 4 hours during off-duty days.

During the prestudy briefing, 41 of the 55 participants responded to a time-of-day preference questionnaire (7). This instrument classifies an individual as being one of five types: (1) definite or (2) moderate morning type; (3) definite or (4) moderate evening type; or (5) neither type. This time-of-day preference measure had not been previously used by USAFSAM/VNE. For this study, extreme time-of-day preferences were considered as possible factors in individual reactions to the early/late training schedule and therefore of possible value in interpreting the subjective fatigue and sleep data.

RESULTS

Only a few of the 55 participants reported complete data for every day of the study. Emergency leaves, illness, cross-country sorties, and most frequently, forgetting, all contributed to the occurrence of missing data. The data from some participants were so meager that they had to be completely discarded. Because of missing data, mean values presented for comparisons in

tables and graphs were not always calculated on the same participants and varied as to sample size. In general, the results presented are based on data from participants who submitted an initial and an end-of-day fatigue checkcard for at least 1 work week.

Time-of-Day Preference

Distribution of time-of-day preferences for T-37 and T-38 participants is summarized in Table 1. Of 41 respondents, 26 (63%) reported no morning nor evening preference, and none of the 41 could be classified at the extremes as definite morning or evening types. In the T-37 group, 8 of 22 respondents were moderate morning types; in the T-38 group, only 3 of 19. While these data are of general interest, the absence of extreme preferences made it impractical to further evaluate the relationship between time-of-day preferences and sleep or fatigue scores in this study.

TABLE 1. NUMBER OF PILOTS CLASSIFIED IN EACH TIME-OF-DAY PREFERENCE CATEGORY

Category	T-37	T-38	Total
Definite morning type	0	0	0
Moderate morning type	8	3	11
Neither type	12	14	26
Moderate evening type	2	2	4
Definite evening type	0	0	0
TOTAL	22	19	41

Sleep

The mean number of hours slept each night of the week by student and instructor pilots when on the early and late schedules are presented in Figure 3. These data are further summarized in Table 2 for nights preceding duty and nonduty days.

In general, pilots (students and instructors) in both aircraft (combined) acquired 6.8 hours of sleep per night during the work week when on the early schedule and 8.6 hours when on the late schedule. On the two weekend nights, pilots coming off the early schedule reported an average of 9.5 hours per night, and those coming off the late schedule, 9.0 hours. The average weekend nightly sleep always increased more than 2 hours after an early work week. After a late work week the sleep increased less than 1 hour--except for the T-37 student group, who slept less on the weekend after a late work week than during that week.

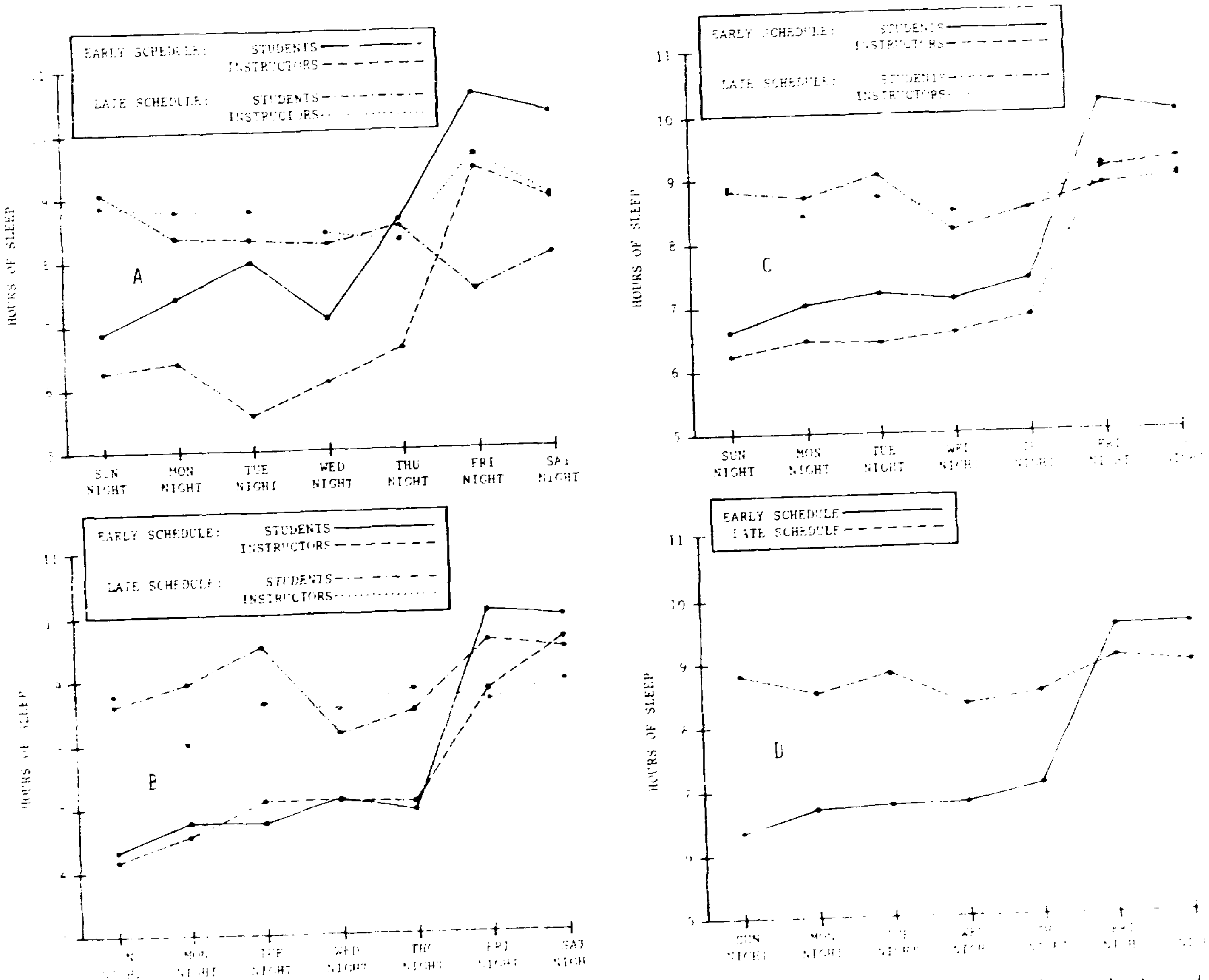

Figure 3. Mean hours slept each night by (A) student and instructor T-37 pilots; (B) student and instructor T-38 pilots, (C) all student and instructor pilots, T-37 and T-38 combined; (D) all pilots combined.

TABLE 2. AVERAGE HOURS SLEPT/NIGHT FOR NIGHTS PRECEDING DUTY DAYS (A) AND WEEKEND DAYS (B), AND ALL 7 NIGHTS COMBINED (C)

	Early A	Early B	Early C	Late A	Late B	Late C
T-37						
Student	7.6	10.4	8.4	8.5	7.8	8.3
Instructor	6.2	9.1	7.1	8.6	9.3	8.8
T-38						
Student	6.8	10.0	7.7	8.7	9.5	9.0
Instructor	6.8	9.2	7.5	8.6	8.8	8.6
T-37 and T-38 Combined						
Students & Instructors (combined)	6.8	9.5	7.5	8.6	9.0	8.7

Much of the variability in the T-37 and T-38 data presented in Figure 3 (A and B) may be a result of the small sample sizes (in most cases n < 20) on which the means were calculated. Because the T-37 and T-38 sleep data demonstrated similar patterns, increased stability in the means could be achieved by combining the data across aircraft types to produce the more discriminating presentation in Figure 3(C). Here the similarities in the student and instructor sleep patterns, and the differences in the patterns for the early versus late schedules, are apparent. By again combining the data across student and instructor pilots, the different weekly sleep patterns relating to the early and late schedules are singularly presented in Figure 3(D).

Bedtimes and arising times were evaluated to determine when the participants were reducing their sleep time when assigned to the early schedule. Mean bedtimes and rising times are presented in Figure 4 for instructors and students in each squadron and for combined squadrons and pilots. Figure 4 shows that on nights preceding duty days the instructors and students assigned to the early schedule retired about 1 1/2 hours earlier (except on Sunday nights), but arose over 3 hours earlier, than when on the late schedule.

To the sleep survey question "Do you feel like you could have used some more sleep?" 45 pilots responded in the affirmative. When arising on the early schedule, 18 (of 21) T-37 pilots and 18 (of 24) T-38 pilots felt that they needed more sleep at least 75% of the time. When arising on the late schedule, only 2 of the T-37 and 5 of the T-38 pilots felt the need for more sleep this frequently. (See Table 3.)

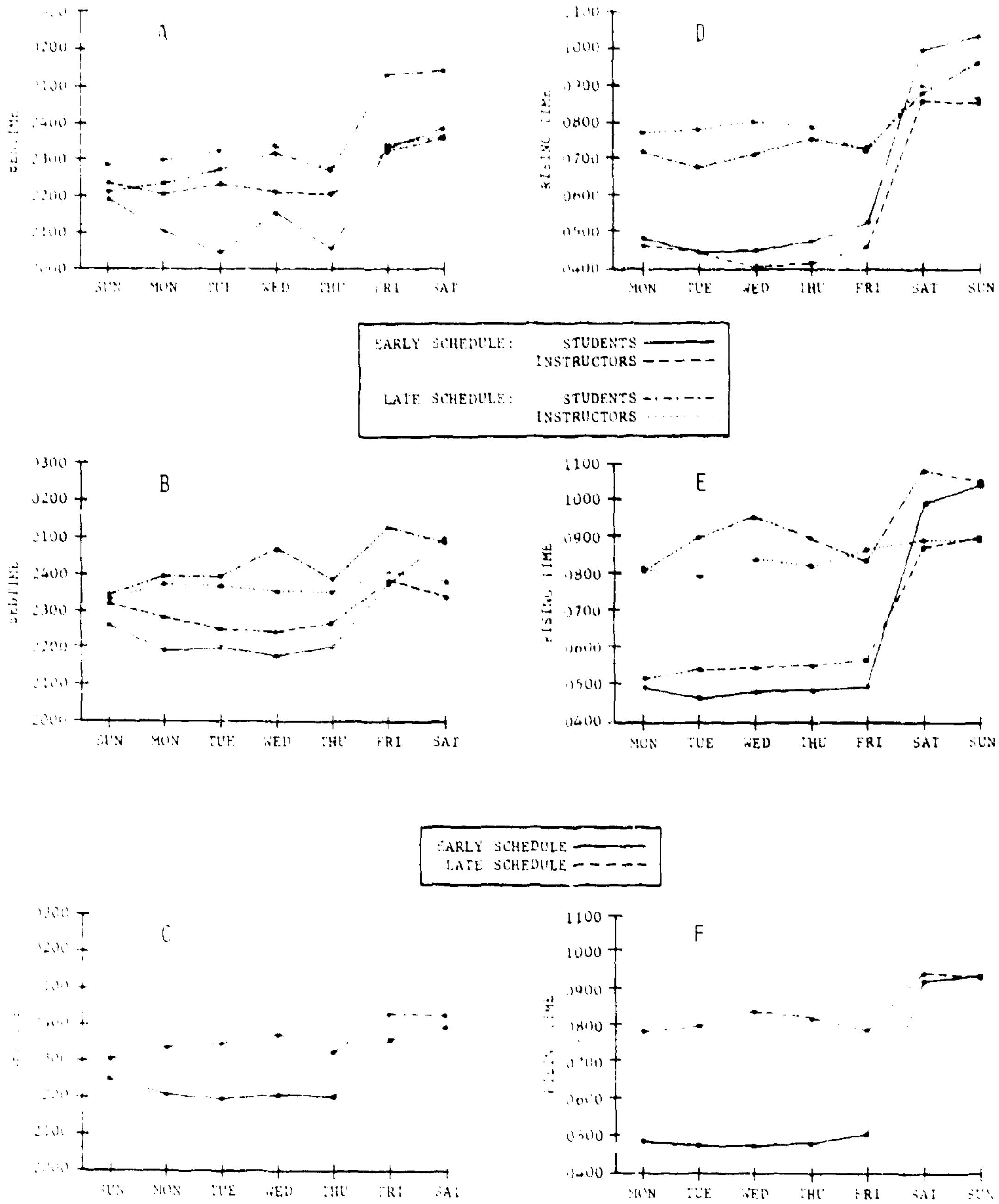

Figure 4. Mean daily bedtimes (A-C) and rising times (D-F) for:
T-37 Pilots (A and D)
T-38 Pilots (B and E)
All pilots combined (C and F)

TABLE 3. NUMBER OF PILOTS DESIRING MORE SLEEP UPON ARISING FOR DUTY

Time more sleep needed	Schedule:	T-37 Pilots (21) Early	T-37 Pilots (21) Late	T-38 Pilots (24) Early	T-38 Pilots (24) Late
100%		10	1	10	2
75-99%		8	1	8	3
50-74%		1	6	5	1
<49%		2	13	1	18

Subjective Fatigue

Collection of subjective fatigue scores was planned for about every 4 hours to permit analysis of progressive within-day changes. Too many data were missing to permit such an analysis; however, daily comparisons could be made between fatigue scores reported upon arising with those reported at the end of a duty day. Weekends were excluded because of missing data. Graphic summaries of the daily comparisons are presented in Figures 5A and 5B for the T-37 and T-38 participants, respectively, and in Figure 5C for all participants combined. Table 4 presents overall mean subjective fatigue scores for both schedules, complementing Figures 5A-5C.

The fatigue scores for pilots and instructors were fairly similar in both the T-37 and T-38 squadrons. As best summarized in Figure 5C and the bottom row of Table 4, an overall mean score of about 10, indicating mild fatigue, was reported at the start of a duty day on the early schedule while a score of about 13, reflecting feelings of alertness, was reported on the late schedule. At duty-day end under both schedules, average fatigue scores of about 8 were reported, indicating moderate fatigue. There were no apparent systematic day-to-day changes in the average fatigue scores reported across the days of the week.

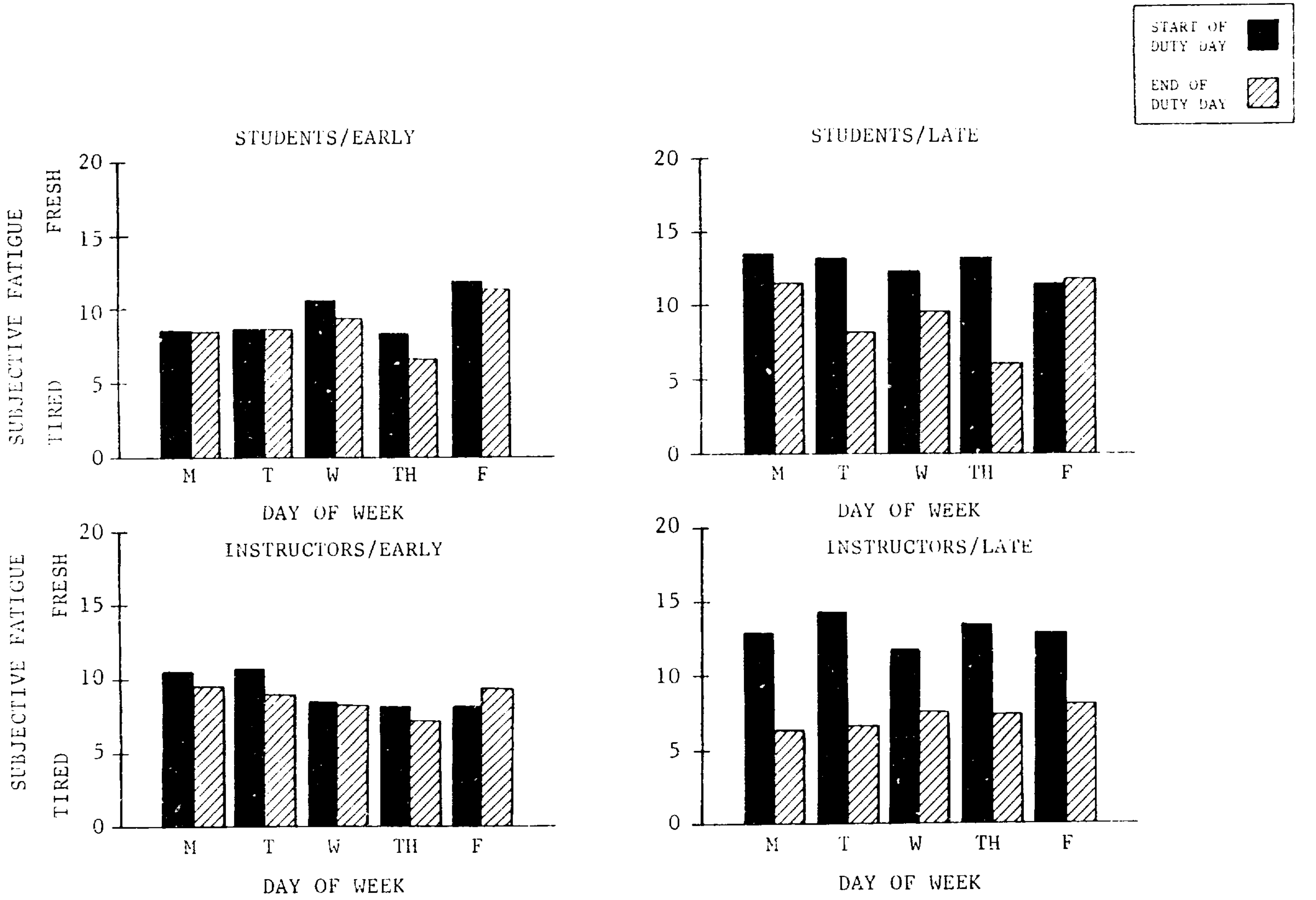

Figure 5A. Mean subjective fatigue scores for student and instructor T-37 pilots.

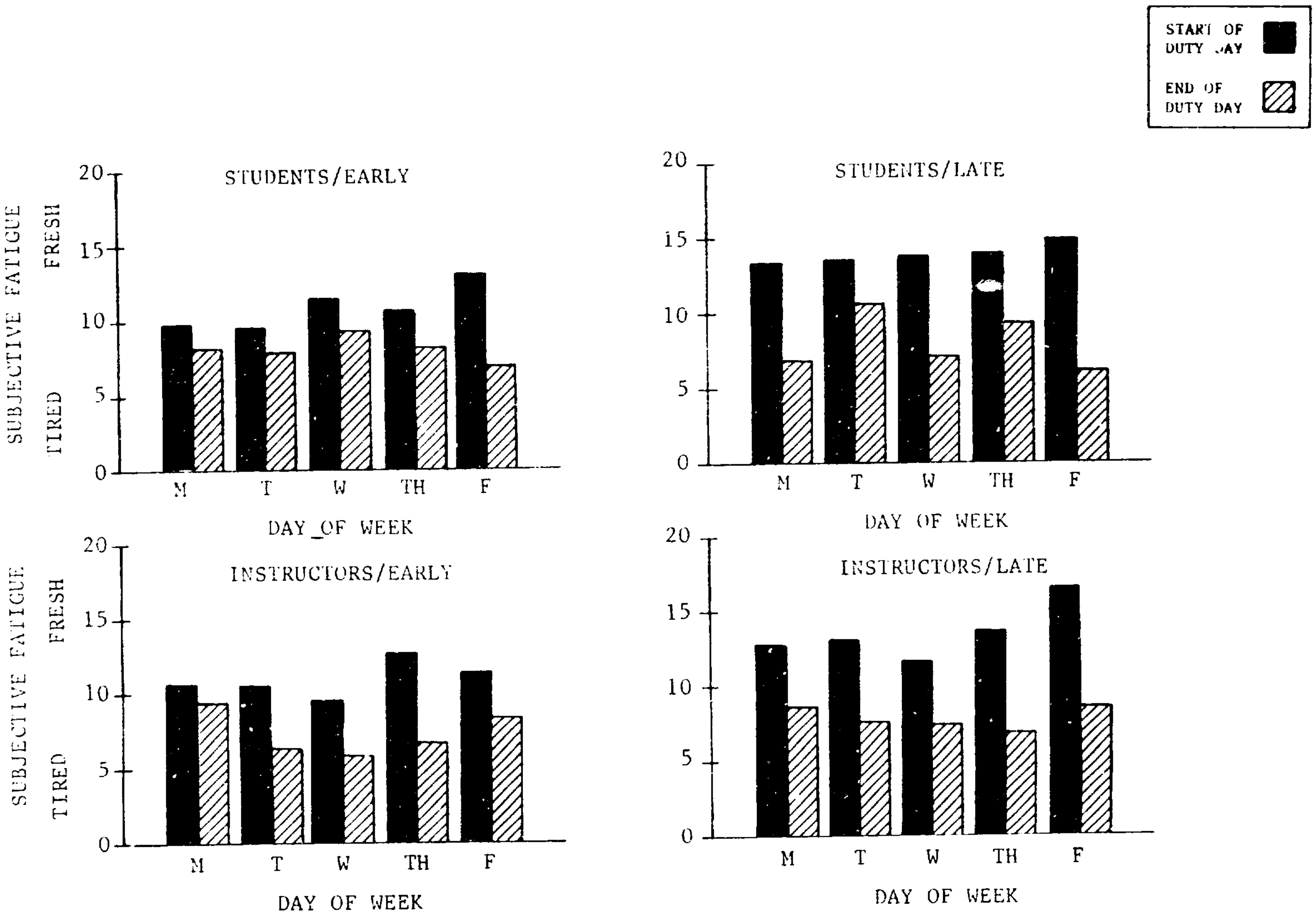

Figure 5B. Mean subjective fatigue scores for student and instructor T-38 pilots.

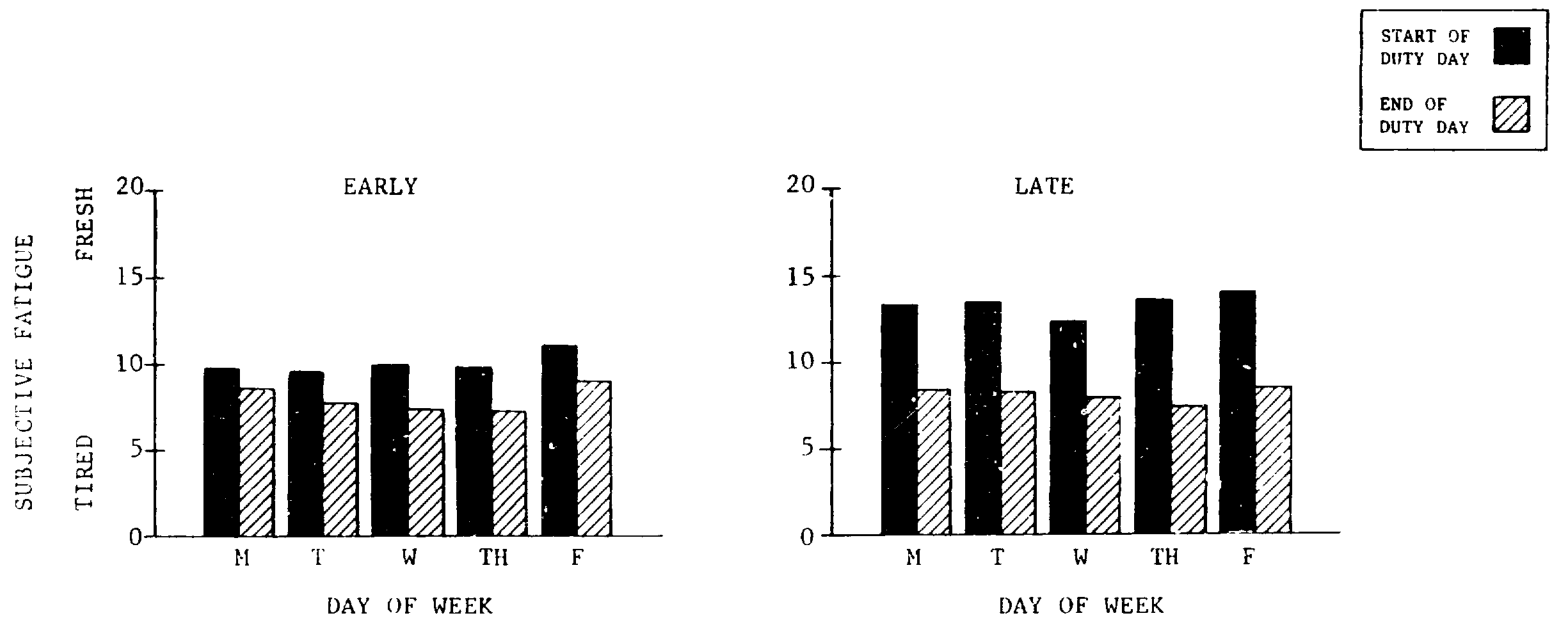

Figure 5C. Mean subjective fatigue scores for all pilots.

TABLE 4. OVERALL MEAN SUBJECTIVE FATIGUE SCORES REPORTED AT THE START AND END OF DUTY DAYS

Pilots	Schedule:	Early		Late	
	Duty Day:	Start	End	Start	End
T-37 (N=20-40)					
Students		9.5	8.8	12.6	9.4
Instructors		9.1	8.5	13.1	7.2
T-38 (N=27-44)					
Students		10.8	8.0	13.9	7.9
Instructors		10.9	7.2	13.5	7.7
T-37 & T-38 (N=128-147)					
Combined		10.1	8.0	13.3	8.0

Scores:
Above 11 = alert
8-11 = moderate to mild fatigue
7 and below = severe fatigue

DISCUSSION

Duty Days

Young, healthy adults working typical "8-5" daytime jobs acquire 7.5-8.0 hours of sleep each night of the work week (Sunday-Thursday nights) (9). Compared to this reference value, both student and instructor pilots acquired about 0.5-1.0 hour more sleep per night when assigned to the late schedule and forfeited about 1 hour of sleep per night when on the early schedule. These variations relate to the atypical UPT duty schedules.

Both student and instructor pilots made some attempt to adjust their sleeping times to the early schedule by going to bed more than 1 hour earlier than when on the late schedule, except for Sunday nights. Because of the very early arising time, however, they had a net loss in total hours slept. Associated with the early rising were subjective reports of a need for more sleep and subjective fatigue scores indicative of inadequate rest and sleep. In contrast, when on the late schedule, the pilots awoke feeling rested and reported fatigue scores consistent with those reported in previous studies by subjects arising from a full night of sleep (4).

The effects of partial sleep loss on fatigue and performance have been studied extensively, but findings have not been consistent. The extensive manipulations that can be made in sleep schedules and work/rest cycles

account for much of the variation in findings. Most people continue to function with minimal impairment during an abruptly induced restricted sleep regimen, and when the restriction is removed they return to their usual sleep schedule. They do not adapt to, nor do they prefer to continue, a restricted sleep schedule longer than necessary. In a laboratory study particularly relevant to this effort, daily hours slept by young adults were abruptly reduced from 8.0 (2330-0730) to 5.5 hours (0100-0630) per night for 60 days (13). The subjects' sleep-onset times decreased during the first week, then stabilized. Getting up in the morning was reported to be difficult during the entire 60 days, though the greatest difficulty was during the first week. Feelings of drowsiness also were most frequently reported during the first week. No performance decrements occurred in memory and problem-solving abilities, although a slight but significant decline did occur in auditory vigilance performance.

A few studies have evaluated the effects of gradually reducing (e.g., 0.5 hour every 2 weeks) nightly sleep to 4.5 hours (8,9). The subjects reduced their sleep by going to bed later; their time of getting up remained constant. In general, feelings of fatigue and the need for more sleep began to be reported when sleep was reduced by 1.0-1.5 hours. Performance was maintained on memory and problem-solving tasks but deteriorated somewhat on the auditory vigilance task. When the subjects returned to ad lib sleep regimens, they did not revert to sleeping 7-8 hours per night; instead, they required only 6.0-6.5 hours nightly. Feelings of fatigue appeared to set the lower limits for hours slept.

Over a 24-hour period, feelings of fatigue vary systematically, demonstrating a circadian rhythm just as reliable as those established for several physiological functions. The circadian rhythm in body temperature is one of the best documented for a physiological measure (1). Typical baseline circadian patterns for oral temperature and subjective fatigue data collected simultaneously from 16 subjects over a 3-day period are presented in Figure 6. The correspondence between the two baseline patterns is notable and well established. Similar within-day patterns of fatigue scores would likely have been demonstrated in the present study, for both the early and the late schedules, had data collection been more complete.

The early schedule tends to resist the typical daily temperature and subjective fatigue circadian patterns, whereas the late schedule is more compatible. A seemingly simple solution to overcome the reduced sleep reported when on the early schedule would be to encourage the pilots to advance their bedtimes even more to fully compensate for the early arising times. As depicted in Figure 6, however, this adjustment may not be physiologically feasible or desirable. Bedtimes as early as 2000 would interfere with study and social activities. Such bedtimes would also align with peak body temperature and subjective fatigue scores that reflect, respectively, a state of arousal and feelings of alertness. Futhermore, feelings of fatigue are greatest when body temperature is lowest, between 0300 and 0500--the time of day that the student and instructor pilots must awaken to report for an early-schedule duty day.

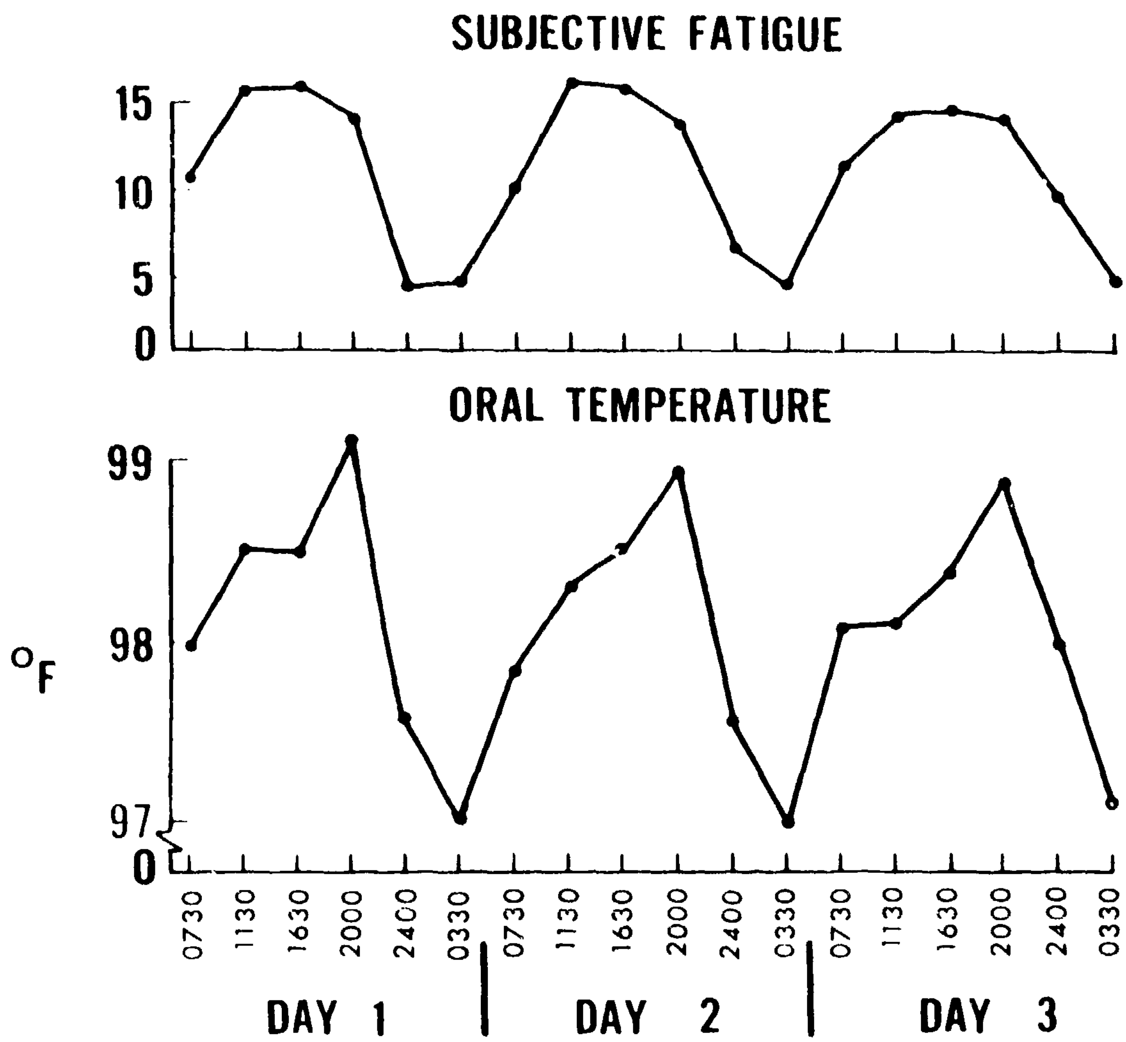

Figure 6. Typical circadian rhythms for subjective fatigue scores (from SAM Form 136) and oral temperature.

Weekend Days

The amount of sleep required to recover from a reduced sleep schedule is not linearly related to the amount of sleep deficit. Laboratory and operational studies have consistently demonstrated the dramatic recovery value of 1 night of good quality, extended (ad lib) sleep following extreme modifications and restrictions in work/rest schedules (4,9,14). In this study the student and instructor pilots averaged more sleep on the weekends (Friday and Saturday nights) than they did during the work week. How much of this extra sleep was physiologically compensatory for sleep deficit accumulated during early-schedule duty weeks and how much resulted from simply sleeping-in cannot be precisely determined. However, some of the hours slept on the weekends were apparently of a catch-up nature, as the average time slept was greater after a week on the early schedule than on the late schedule.

CONCLUSIONS

As indicated by both sleep logs and subjective fatigue reports, the UPT schedule of alternating weekly between early-morning and late-morning report times causes both student and instructor pilots to feel less than completely rested at the start of their early-morning duty days. The level of fatigue reported appears to be modest, particularly for the time-of-day, and not of dramatic operational impact except for the fact that this is a learning situation for the student pilots. Significant performance impairment has seldom been detected for active, well-learned tasks as a result of 1-2 hours per night sleep reduction. For new, unmastered tasks and well-learned but passive "watchkeeping" tasks, however, performance deterioration has been found to sometimes occur. The elevated fatigue at the beginning of each early-schedule day suggests that the pilots may have less reserve capacity and may have to try harder to maintain acceptable levels of attention and performance than when on the late schedule. This applies especially to student pilots whose flying skills are not well learned, integrated, and automatic.

The alternating weekly schedule impacts on the pilots in two ways. First, the schedule requires weekly readjustment of sleep and duty schedules. In most cases, the alternating schedule is much more demanding and tiring than is permanent assignment to an uncommon work schedule. The literature-base indicates that some degree of adaptation and adjustment would occur after several consecutive weeks of permanent assignment to the early schedule. Personal, family, and, to some extent, physiological function would better stabilize to accommodate the duty schedule. However, given the requirement for both day and night flight training in all phases of UPT and the fact that the pilots would revert to more customary schedules on days off, this does not appear to be a feasible means of reducing schedule-related pilot fatigue. (Although documentation cannot be located, the authors have been told of a study conducted at Williams AFB, Arizona, in 1978. Training flights in a T-37 squadron rotated between the early and late schedules every 2 weeks. This schedule was well accepted for a month, but resulted in several complaints of marked fatigue when on the early schedule during the second month.)

Second, the pilots on the early-morning schedule acquire less than desirable amounts of nightly sleep because they are required to advance their arising times to much earlier than normal. This earlier time contributes as much, or more, to the fatigue reported at the beginning of each early-morning day as does the reduced amount of hours slept. In an attempt to compensate, the pilots advance their bedtimes; but this maneuver does not completely compensate, especially for a week's time. In fact, advancing a sleep period has been shown to be more stressful than delaying a period (2). Our inability to evaluate progressive changes in fatigue scores within each day prohibited a more thorough evaluation of UPT schedule impact. However, subjective fatigue scores and established daily psychophysiological patterns indicate that starting the UPT early-morning duty day 1-1 1/2 hours later (0630-0700) might considerably reduce early-morning pilot fatigue and sleepiness.

RECOMMENDATIONS

The findings and conclusions from this study are of a preliminary nature. Because the data were incomplete, liberties have been taken that would have been inappropriate for more refined statistical analyses.

At minimum, the findings from this evaluation provide empirical data for describing to both student and instructor pilots the importance of acquiring adequate rest and sleep. The greater stress of the early-week schedule should be emphasized.

If operationally feasible, starting the early-week duty day at 0630-0700 may reduce early-morning pilot fatigue and sleepiness.

Future evaluations should concentrate on in-depth data collection from 20-25 pilots who are dedicated to the study, thereby minimizing missing data and permitting accurate description of both between-day and within-day patterns of response.

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